
MA Sustainable Forest Bioenergy Initiative

MA BEWG
MWCC - Gardner, MA

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# Massachusetts Potential for Biomass Energy Crops

# Regional Economic Impact Analysis: Energy from Forest Biomass

David T. Damery, Ph.D.
David Timmons
Geoffrey Allen

University of Massachusetts, Amherst
Department of Natural Resources Conservation
Department of Resource Economics

# Funders - Acknowledgement


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- Massachusetts Technology Collaborative

# Background

- SFBI Elements
  - Forestry Infrastructure Development Industry Education and Outreach
  - State Forests Resource Planning, Mgt. & Infrastructure Improvements
  - Resource Assessment and Strategic Plan of Biomass Supply Infrastructure and Market
  - Forest Impact Assessment with Increased Residue Removals
  - Forest Industry Training and Economic Development Programs
  - Energy, Environment and Climate Integration – State Positions and Public Outreach
  - Biomass Project and Market Development
  - Project Management and Reporting

# MA Potential for Biomass Energy Crops

Sub-Task 1.3 Part 7.

**Assess MA agricultural lands for dedicated crop opportunities**

- Establish estimates for crop yields, production cost, price, opportunity costs (for switchgrass and willow).
- Characterize attributes of agricultural lands appropriate for dedicated energy crops.
- Estimate total MA acres appropriate for dedicated energy crops (growing conditions, set aside/protected lands, unproductive farmland, etc.)
- Recommend a plan for establishing dedicated energy crop trials.
- Prepare report documenting assessment of MA dedicated energy crops

# MA Potential for Biomass Energy Crops - Benefits

- Sustain and reinvigorate the agricultural economy;
- Can create traditional agricultural landscapes;
- Currently mown fields (maintenance) could be used to produce biomass crops;
- Some biomass crops (switchgrass) are adapted to smaller scale production appropriate for Massachusetts;
- Bulky and difficult to transport – if Massachusetts is to use biomass energy, most of it must come from nearby.

# Research Methodology

- Biomass Crop Production Costs
- Assess Potential Biomass Energy Demand in 5-county (W. Mass) area.
- Review crop production in 3 Scenarios
  - Switching of crops on existing farmland
  - Use of farmland that is no longer part of active farms
  - Conversion of some current forestland back to farmland

# Coppiced Willow

- Planting
- 3-4 years of growth to cutting
- 22 year stand life

# Switchgrass

- Planting
- Annual harvest (multiple passes)
- 10 year “perennial life”



http://www.nrel.gov/biomass/photos.html

# Potential of Crops - per acre

- Wood from the Forest - lowest, low management
- Willow - in the middle
- Switchgrass - highest, but with intensive management and cost

# Crop Comparison

| Fuel | Wood Chips | Willow Chips | Switch-grass |
|---|---|---|---|
| Tons/acre | 1.1 | 4.7 | 4.0 |
| Moisture | 45% | 45% | 12% |
| MMBtu/ton | 9.3 | 8.8 | 13.8 |
| MMBtu/acre | 10.0 | 40.8 | 54.8 |

# Willow Costs (Tharakan, 2005)

| | Farm gate price/ton | Plant gate price/ton |
|---|---|---|
| Base yield | $24.04 | $32.34 |
| Base yield + CRP | $13.59 | $21.89 |
| Increased yield | $21.45 | $27.95 |
| Increased yield + CRP | $12.76 | $19.56 |

# Switchgrass Production Costs

(Duffy & Nanhou, 2002)

| Expense | Cost ($ / hectare) |
|---|---|
| Establishment/seeding | $67.29 |
| Pre-harvest machinery & labor | $29.14 |
| Operating expense (fertilizer) | $110.11 |
| Harvesting expense | $256.06 |
| Land rent | $123.46 |
| TOTAL COST | **$586.06** |

# Switchgrass Production Yields

(Duffy & Nanhou, 2002)

| Yields and Costs | M.C. = 12% |
|---|---|
| Yield per ha, Mg | 8.96 |
| Cost per Mg | $65.41 |
| Yield per acre, short tons | 3.99 |
| Cost per short ton | $59.46 |

# Energy Cost for Crop Fuels

| | Wood chips | Willow | Switchgrass |
|---|---|---|---|
| Cost/ton, farmgate | | $24.04 | $59.58 |
| Farm-plant transport | | $8.30 | $8.30 |
| Cost/ton, Plant gate | $30.75 | $32.34 | $67.88 |
| Moisture content | 45% | 45% | 12% |
| Mmbtu/ton | 9.25 | 8.77 | 13.75 |
| Cost per MMbtu | $3.32 | $3.69 | $4.94 |

# Demand Estimate (for illustration)

- 5 W. Mass counties use of coal and oil = 35.0 trillion Btu (140.7 trillion all of MA) (DOE 2004)
- New 165 MW Biomass electricity = 17.8 trillion Btu
- Upper limit 35.0 +17.8 = 52.8 trillion Btu

# Supply Scenarios (acreage)

- Scenario 1: 20% of Farmland
- Scenario 2: All “idle” farmland put into use
- Scenario 3: 20% of Forestland “reconverted” back to farming

# Biomass energy from Crops

| | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Farm acres | 66,968 | 59,694 | 566,959 |
| Biomass tons/acre | 3.0 | 3.0 | 3.0 |
| Million Btu/ ton | 14.0 | 14.0 | 14.0 |
| Lost forest acres | | | 566,959 |
| Biomass tons/acre | | | 1.1 |
| Million Btu/ ton | | | 9.3 |
| Net Trillion Btu supply | 2.8 | 2.5 | 18.1 |

Break!


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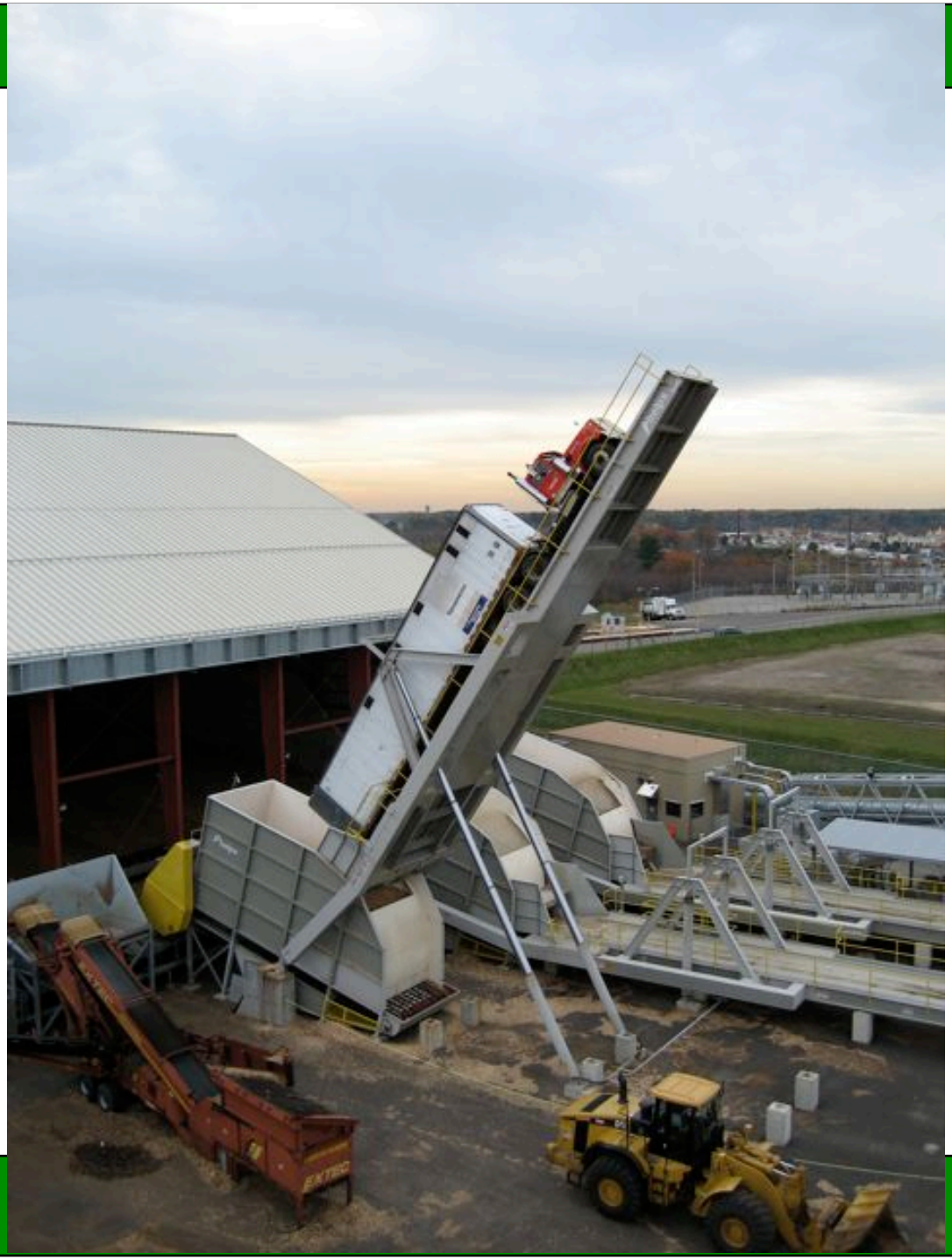


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# Regional Economic Impact Study

- Regional Demand for Biomass Energy
- Designing a Massachusetts "Build-out" Scenario
- Construction and Operating Scenarios
- Chip Demand and Supply Infrastructure
- Economic Impacts - Employment, Labor Income and Economic Output

# Electricity Demand - The Regional Market, 2015

- Renewable Energy - Driven by RPS (CT, MA & RI)
- Biomass Energy - a “bridge” technology, PV and Wind to follow

| | |
|---|---|
| Tot. Demand, GWh, CT,MA,RI | 6,929 |
| Biomass portion of RPS | 29% |
| Biomass electricity, GWh | 2,009 |
| MA Generation Percentage | 65% |
| MA Biomass Electricity, GWh | 1,306 |
| MA Biomass Generating, MW | 165.7 |

# Electricity Generation

# Designing a MA Biomass Related Build-out Scenario

- Two - 50 MW plants (a la Schiller, Russell)
- Two - 25 MW plants (other proposals)
- Three - 5 MW combined heat and power (campus, MWCC…)
- 25 - 5MM Btu heat-only facilities

# Estimated Plant Construction Costs

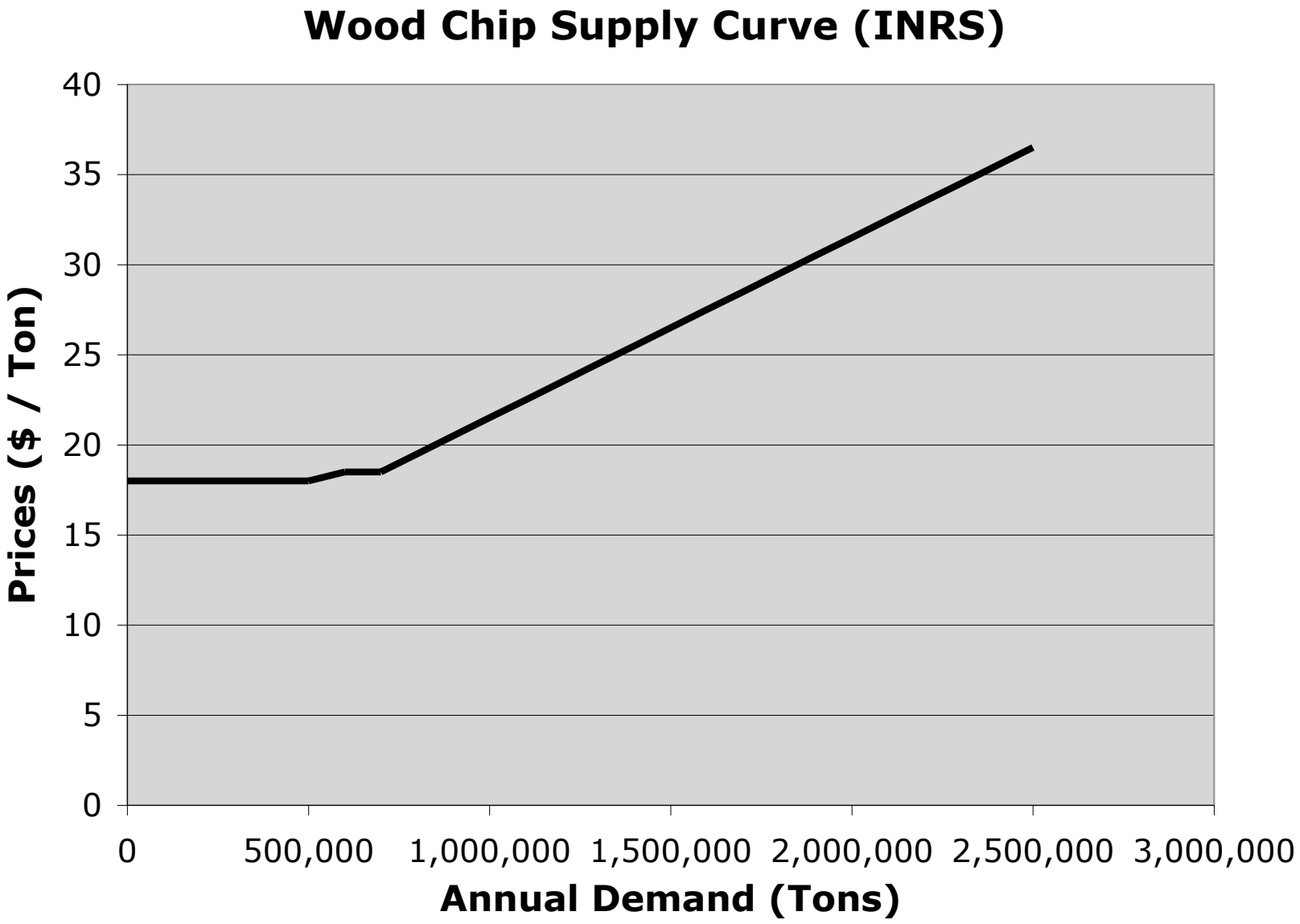
- Variety of prior studies and expert opinion
- Adjusted to 2006 Dollars
- $2,154,950 per MW
- Total Cost, 165 MW = $377 Million

# Estimated Plant Operating Costs, 50 MW Plant (INRS 2002, revised)

| | $ per MW (2006) |
|---|---|
| payroll | 43,680 |
| Property taxes | 16,800 |
| Supplies and services | 29,867 |
| maintenance | 26,133 |
| Utlilities | 31,733 |
| Total per MW | 148,213 |
| Total for 50 MW plant | $7,410,667 |

# Estimated Wood Chip Demand

| | |
|---|---|
| MW Electric capacity | 165 |
| Plant capacity factor | 90% |
| Annual GWh/MW capacity | 7.9 |
| Mbtu/GWh | 3,413 |
| Annual MMBtu/MW capacity, net | 26,908 |
| Plant efficiency | 28% |
| Annual MMBtu/MW capacity, gross | 96,100 |
| MMBtu heat content/ton chips | 9.25 |
| Ton chips/MW capacity | 10,389 |
| Annual tons wood chip demand (elec) | 1,714,222 |
| Annual tons wood ship demand (heat) | 31,250 |
| Total Demand | 1,745,472 |


Wood Chip Supply Curve (INRS)
Prices ($ / Ton)
40
35
30
25
20
15
10
5
0
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
3,000,000
Annual Demand (Tons)

# Chip Supply Jobs - In The Woods

(Westbrook, Greene et al. 2006, Kingsley 2007)

- Knuckleboom loader & chipper
  - One crew member
- Trucking - ferry chips from woods to plant
  - Two trucks, two drivers
- Additional felling, skidding and delimbing
  - 1.5 crew members
- 180 tons chips/day, 43,200 tons annually
- 24 NEW Crews needed = 109 jobs

# Chip Production Equipment

| Equipment | Cost | No. | % chips | Total |
|---|---|---|---|---|
| Feller-buncher | $267,689 | 1 | 50% | $133,844 |
| Grapple skidder | $199,920 | 1 | 50% | $99,960 |
| Stroke-delimber | $366,165 | 1 | 50% | $183,083 |
| Knuckle-boom loader | $186,461 | 1 | 100% | $186,461 |
| Chipper | $597,400 | 1 | 100% | $597,400 |
| Trucks | $142,140 | 2 | 100% | $284,280 |
| Total | | | | $1,485,028 |

# Economic Effects

- Direct - Jobs, in woods, in plant, construction
- Indirect - Economy wide effects on business activities for off-site suppliers to the directly affected businesses.
- Induced - household generated consumption of food, clothing, shelter and other goods/ services resulting from new payroll of directly effected businesses and suppliers

# Construction Phase

Accrues over 5 Year construction period

| | 5 WM Counties | Rest of MA | Total MA |
|---|---|---|---|
| Jobs | 4,657 | 346 | 5,003 |
| Labor Income ($mil. 2006) | $225 | $11 | $236 |
| Output ($mil. 2006) | $430 | $56 | $486 |

# Operating - New Fuel Supply

| | 5 WM Counties | Rest of MA | Total MA |
|---|---|---|---|
| Jobs | 216 | 56 | 272 |
| Labor Income ($mil. 2006) | $8 | $4 | $12 |
| Output ($mil. 2006) | $39 | $12 | $51 |

# Plant Operations

| | 5 WM Counties | Rest of MA | Total MA |
|---|---|---|---|
| Jobs | 224 | 97 | 321 |
| Labor Income ($mil. 2006) | $14 | $5 | $19 |
| Output ($mil. 2006) | $18 | $10 | $28 |

# Conclusions

- An Economic Opportunity
- Contributes significantly to RPS policy goals
- Need new logging capacity, what to do with sawlogs?